Technical Note

Influence of Regulators in Controlling Upstream Water Depth

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Abstract: Control of irrigation canals usually consists of control of water levels upstream from regulators or check structures. Regulators provide the necessary head to offtakes. Generally, influence factor is used to express the extension of the backwater curve effect within the controlled reach. This factor shows how a change in water depth exercised by a regulator can influence the water surface profile along an irrigation canal. No direct equation is available in the technical literature up until now for calculating this factor on the basis of the steady gradually varied flow theorem. In current research, using the steady gradually varied flow equation for a prismatic canal, an elegant algebraic equation for this factor is derived. Control of water levels upstream from regulators is an important application of this equation in irrigation networks. **DOI: 10.1061/(ASCE)IR.1943-4774.0000341.**

CE Database subject headings: Irrigation; Canals; Water levels; Backwater.

Author keywords: Influence factor; Irrigation canal; Regulators and offtakes; Backwater curve; Control of water levels; Upstream control.

Introduction

Operations along irrigation canals aim to reach a desired status to satisfy the preferred delivery pattern. In a free surface delivery network, the control of the water surface profile along an irrigation canal is achieved by regulators that adjust water depth at specific points to guarantee a constant head at offtakes along the canal. The degree of influence exercised by the regulator on offtakes can be determined using influence factor (Renault 1999). The influence factor indicates the variation of water depth at an upstream offtake attributable to the variation of water depth at a regulator. This factor ranges between 0 and 1. The influence factor is close to 1 if an offtake is highly under the influence of a downstream regulator (offtake is close to a regulator) and is equal to zero for uniform flow conditions. The value of the influence factor depends on the position of the offtake along the backwater curve. This factor may be determined by hydraulic computation or experimental measurements (Renault 1999).

In between real experiments and fully unsteady simulations of irrigation canals, analytical approaches of hydraulic steady state can be easily handled by managers and may allow them to investigate, to a limited extent, the behavior of the canal (Godaliyadda 1998). A simple model also requires less computational time and effort than a complex one and can therefore more easily be used by design engineers. In the following, using the steady gradually varied flow equation (SGVFE), an analytical equation for the influence factor is derived.

Influence Factor Equation

The attention in this paper is focused on upstream control. A water structure that controls a variable located upstream from it is called upstream control (Malaterre et al. 1998). In upstream control systems, the objective is to control the water depth upstream of the regulators within a specified variation around the target water depth. This target has usually been set to allow offtakes under the influence of the regulator to be fed properly (Renault et al. 2007). The amount of backwater at the downstream end of a canal reach has a huge effect on its controllability (Strelkoff et al. 1998). A reach is considered to be the pool between two consecutive regulators (Renault 2000). The control of the water depth upstream of a regulator decreases with distance and ultimately can become negligible when depth asymptotically approaches its normal value. Offtakes are analyzed either under the influence of a regulator or under uniform flow conditions (Fig. 1). The water depth in a canal not under the influence of downstream regulation is considered as normal flow depth. Normal depth depends on discharge and local hydraulic characteristics. In a canal reach under uniform flow conditions, water depth cannot be controlled directly. Consequently, every change in the main supply discharge is likely to bring about a change in the water level in the canal (Godaliyadda 1998). This issue has to be taken into account in the operation of offtakes in the reach.

For the zone under the regulator influence as shown in Fig. 1, the governing equation (SGVFE) of a prismatic regular canal is (Chow 1959; Subramanya 1986)

$$dx = \frac{1 - \mathrm{F}^2}{S_0 - S_f} dy \tag{1}$$

in which

$$\mathrm{F}^2 = \frac{Q^2 T}{gA^3} \tag{2}$$

$$S_f = \frac{n^2 Q^2 P^{4/3}}{A^{10/3}} \tag{3}$$

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Note. This manuscript was submitted on September 29, 2009; approved on January 21, 2011; published online on January 24, 2011. Discussion period open until February 1, 2012; separate discussions must be submitted for individual papers. This technical note is part of the ***Journal of Irrigation and Drainage Engineering***, Vol. 137, No. 9, September 1, 2011. ©ASCE, ISSN 0733-9437/2011/9-620–623/$25.00.